The Accelerator Challenge - from $10^{32}$ to $10^{34}$ to $10^{36}$

Jonathan Dorfan
Director Emeritus, SLAC
$10^{32}$ to $10^{34}$ cm$^{-2}$ sec$^{-1}$

The Era of the mid 1980s to mid 2000s
WHAT HAS LED TO THE INTENSE INTEREST IN CP VIOLATION IN B?

ARGUS & CLEO HAVE MEASURED LARGE MIXING IN $B^0 / \bar{B}^0$ SYSTEM

B LIFETIME IS LONG ($\gtrsim 1$ psec)

SILICON VERTEX METHODS REPRESENT A NEW LEVEL OF DETACHED VERTEX PRECISION

PROSPECT OF MEASURING CP IN B MESON SYSTEM LOOKS MUCH BRIGHTER

THIS WOULD BE THE FIRST OBSERVATION OF CP VIOLATION OUTSIDE OF THE $K^0$ SYSTEM

SUCH MEASUREMENTS WOULD CONSTRAIN THE STANDARD MODEL IN A VERY STRINGENT MANNER

1989

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This led to at least 21 $e^+e^-$ B Factory concepts and proposals ($19\ Y(4S) + 2\ Z0$) and several hadronic machine approaches (HERA-B, ..).

Pier Oddone’s concept of using an asymmetric $e^+e^-$ collider to boost the distance between the two decay vertices was, in the end, the most successful approach. Two colliders, PEP-II and KEKB, were ultimately built.
• Discussions with Ikaros Bigi and Tony Sanda
• “Crazy Asymmetric Idea” just what was needed for CP studies
• Could be done by modifying PEP
  – Two rings: give high luminosity
  – Y(4S): gives high cross section and $B^0 \overline{B}^0$ in coherent state
  – Asymmetry: separated vertices give time evolution

Slide Courtesy of Pier Oddone
Next thrust: Apiaries…..

• APIARY 1: June 1988

Slide Courtesy of Pier Oddone
So What Were the Key Challenges?

1) Technical

2) Quality Control *without* Compromising Integrated Luminosity or Budget or Schedule
1) Technical Challenges
Physics Requirements

1. Integrated luminosity of $\geq 30 \, \text{fb}^{-1}/\text{year}$
   This corresponds to
   \[
   \mathcal{L}_{\text{peak}} = 3 \times 10^{33} \, \text{cm}^{-2} \, \text{sec}^{-1}
   \]
   $2 \times 10^{7}$ seconds
   $\epsilon \approx 50\%$

2. Two storage rings colliding asymmetrically at $Y(4s)$ with $E_{hi} \geq 8 \, \text{GeV}$

3. Beampipe radius $\leq 3 \, \text{cm}$

4. Detector well instrumented for
   $-0.95 \leq \cos \theta_{cm} \leq 0.9$
   This corresponds to restricting the machine components to $\theta_{lab} \leq 300 \, \text{mrad}$ in forward direction

Given the critical importance of the CP physics, it is most desirable to have two $B$-Factories in the world

30 $\text{fb}^{-1} = 3.3 \times 10^{7}$ BB events

Integrated $\mathcal{L}$ Benchmarks:

- CESR: $10^5 \, \text{BB/yr}$ in 1987
- CESR: 1.1-1.5 $\text{fb}^{-1}/\text{yr}$, average 1991-1995

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Choices for $\mathcal{L}$ Optimization are not Wide Ranging:

$$\mathcal{L} = 2.17 \times 10^{34} \ (1+r) \ \Delta \nu \ (\frac{E(\text{GeV}) \ I(\text{amps})}{\beta_y^*(\text{cm})})^{+,-}$$

- $E^{+,-}$ → Given by physics
- $\beta_y^*$ → Limited to $\geq 1 \ \text{cm}$ by bunch length and practical considerations
- $\Delta \nu$ → Beam-beam sets this; Not really a parameter
- $0 < r < 1$ → $r$ is aspect ratio of beams (flat/round). Practical considerations make round beams unmanageable

$\Rightarrow$ Route to HIGH luminosity is HIGH circulating currents

$\downarrow$ Single beam instabilities force you to large # bunches

$\downarrow$ Forces you to two separate rings
What are the technical challenges of $B$-Factory?

Requirements of high current, large number of bunches and hetero-energetic beams leads to:

※ Need a powerful injector, especially for $e^+$. Currents are high and beam lifetimes are short ($\leq 2$ hours)

※ Large synchrotron radiation load. Both thermal management and especially low pressure management are challenging

※ Must provide protection against multibunch instabilities. Bunch spacing $\sim 1m$

※ Must provide interaction region optics which both focuses and separates hetero-energetic beams and keeps the backgrounds to acceptable levels

※ Must have factory performance

The $B$-Factory is thus more of an engineering challenge than an accelerator-physics groundbreaker
CHARACTERISTICS OF PEP II DESIGN: GUIDING PRINCIPLES

- DESIGN MUST BE CONSERVATIVE AT $L = 3 \times 10^{33}$ cgs
- MUST BE FACTORY PRODUCING 30 fb$^{-1}$/year
- MUST ACHIEVE DESIGN SPECIFICATIONS SOON AFTER TURN-ON
  - MAKE DESIGN FLEXIBLE
  - PROVIDE "HEADROOM" / TECHNICAL MARGIN
  - STRESS RELIABILITY; HAVE ENGINEERING STAFF BUILD IT IN FROM THE START
  - CHOOSE PROVEN TECHNIQUES AS MUCH AS POSSIBLE – DO ADEQUATE R&D IN NON-STANDARD AREAS
  - IDENTIFY AS COMPLETE A SOLUTION AS POSSIBLE FROM THE START. IDENTIFY THE MONEY REQUIRED TO IMPLEMENT THIS SOLUTION

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EXAMPLES FROM PEP II DESIGN:

FLEXIBILITY; "HEADROOM"; ABILITY TO UPGRADE LUMINOSITY

- VACUUM CHAMBER IS DESIGNED FOR 3 AMPS; NOMINAL CURRENTS ARE 2.1 AND 1.5 AMPS

- INJECTOR HAS LOTS OF SPARE CAPACITY -- IT WILL STILL PROVIDE SHORT FILLING TIMES ON THOSE DAYS WHEN TRANSMISSION IS POOR

- STRONG WIGGLERS ARE INCLUDED WHICH ARE CAPABLE OF ENSURING EQUAL DAMPING DECREMENTS FOR BOTH BEAMS SHOULD THIS PROVE IMPORTANT (ENERGY TRANSPARENCY)

- TUNE SHIFT IS TAKEN TO BE $\Delta \nu = 0.03$. PEP RAN WITH $\Delta \nu = 0.06$

- VERY ADAPTIVE FEEDBACK SYSTEM -- CAPABLE OF DAMPING ANY TRANSVERSE OR LONGITUDINAL PERTURBATION. FACTOR OF ~2 MORE POWER BUDGETED THAN SIMULATIONS INDICATE IS NEEDED

- MACHINE IS EASILY CONVERTED TO FINITE CROSSING ANGLE BY CHANGING ONLY 1R COMPONENTS. CRAB-CROSSING CAN BE ADOPTED IF PROVEN FEASIBLE/ADVANTAGEOUS
Changing the Center-of-mass
Energy of the PEP-II B factory.

Michael K. Sullivan
May 24, 1993

INTRODUCTION.

All B factory designs are optimized to run at the center-of-mass energy ($W_{cm}$) of the $\Upsilon(4S)$ resonance of the $\Upsilon$ family (10.580 GeV). This note investigates the effect changing $W_{cm}$ has on the design orbits of the beams. The design under study is APIARY 7.5. Methods are shown that attempt to minimize changes in the beam orbits while spanning the $1S$ to $5S$ resonances of the $\Upsilon$.

<table>
<thead>
<tr>
<th>Resonance</th>
<th>$W_{cm}$ (GeV)</th>
<th>$\Delta W_{cm}$ %</th>
<th>$E_1$ (GeV)</th>
<th>$E_2$ (GeV)</th>
<th>$\Delta E_1$ %</th>
<th>$\Delta E_2$ %</th>
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</thead>
<tbody>
<tr>
<td>5S</td>
<td>10.865</td>
<td>+2.7</td>
<td>3.1883</td>
<td>9.2564</td>
<td>+2.7</td>
<td>+2.7</td>
</tr>
<tr>
<td>4S</td>
<td>10.580</td>
<td>0.0</td>
<td>3.1047</td>
<td>9.0136</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3S</td>
<td>10.355</td>
<td>-2.1</td>
<td>3.0386</td>
<td>8.8219</td>
<td>-2.1</td>
<td>-2.1</td>
</tr>
<tr>
<td>2S</td>
<td>10.023</td>
<td>-5.3</td>
<td>2.9412</td>
<td>8.5390</td>
<td>-5.3</td>
<td>-5.3</td>
</tr>
<tr>
<td>1S</td>
<td>9.460</td>
<td>-10.6</td>
<td>2.7760</td>
<td>8.0594</td>
<td>-10.6</td>
<td>-10.6</td>
</tr>
</tbody>
</table>

Constant opening angle constraint.

<table>
<thead>
<tr>
<th>Resonance</th>
<th>$E_1$ (GeV)</th>
<th>$E_2$ (GeV)</th>
<th>$\Delta E_1$ %</th>
<th>$\Delta E_2$ %</th>
<th>IP angle (mrad)</th>
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<tr>
<td>5S</td>
<td>3.1468</td>
<td>9.3784</td>
<td>+1.4</td>
<td>+4.0</td>
<td>-0.27</td>
</tr>
<tr>
<td>4S</td>
<td>3.1047</td>
<td>9.0136</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3S</td>
<td>3.0704</td>
<td>8.7306</td>
<td>-1.1</td>
<td>-3.1</td>
<td>+0.25</td>
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<tr>
<td>2S</td>
<td>3.0182</td>
<td>8.3212</td>
<td>-2.8</td>
<td>-7.7</td>
<td>+0.65</td>
</tr>
<tr>
<td>1S</td>
<td>2.9250</td>
<td>7.6490</td>
<td>-5.8</td>
<td>-15.1</td>
<td>+1.60</td>
</tr>
</tbody>
</table>
WHY THE EMPHASIS ON THE LINAC?

High peak luminosity is not the whole story; \( \langle \varphi \rangle \) is. Lifetime at B factories will be 1-2 hours.

\( \Rightarrow \) Imperative that one be able to inject and top-off very rapidly, very often.

B factories have \( e^\pm \) currents of 1-2 amps to maintain good \( \langle \varphi \rangle \) implies injecting about \( 5 \times 10^{13} e^+ e^- \) in period very short compared to an hour. This is difficult for \( e^- \), extremely difficult for \( e^+ \).

We are very fortunate at SLAC to have a linac which delivers \( 2 \times 10^{10} e^+ e^- \) 120 Hz. Our estimates are that we can fill the B factory in \( \leq 2 \) minutes.
WHATS WRONG WITH CURRENT ALUMINUM GEOMETRY CHAMBERS

WHT B FACTORY?

1. CANNOT HANDLE HEAT LOAD

\[ P = \frac{0.88 E^4 I}{2 \pi p^2} \]

2. CANNOT PUMP CHAMBER - DESORPTION TOO RAPID

\[ \text{LINEAR GAS LOAD (Torr liters/s/m)} = \frac{1.62 \times 10^{-2} E I}{2 \pi p} \]

\[ \eta = \text{DESORPTION COEFF. DEPENDS ON MATERIAL, AMOUNT OF \textit{scrubbing}.} \]

SOLUTIONS:
1. ALUMINUM ANTE /CHAMBER

2. STANDARD SIZE CHAMBER MADE FROM COPPER.

WE HAVE A DESIGN USING COPPER WHICH SOLVES THESE TWO PROBLEMS. EXAMPLE OF WHERE LARGE PEPPING RADIUS IS OF BENEFIT.
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Low Energy Ring
Vacuum Chamber Processing

- Magnet Chamber Oven
- Pumping Chamber
- TN Coating of Pumping Chamber
- Photon Stop
THE ACCELERATOR CHALLENGE

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The Accelerator Challenge

Cornell Workshop
Sept 1990

BACKGROUND COUPLED WITH BEAM SEPARATION ARE CLEARLY ONE OF THE LEADING CHALLENGES!

HOW DO WE PLAN TO SEPARATE THE BEAMS?

OUR PRIMARY SCHEME IS:

HEAD-ON COLLISIONS, MAGNETIC SEPARATION.

OUR PROPOSAL WILL ALSO HAVE A CRAB CROSSING OPTION, WITH SMALL (~ 25mrad) CRAB ANGLE.

IT HAS BEEN OUR DESIRE TO SEE IF WE COULD DESIGN A HEAD-ON SCHEME WITH ACCEPTABLE BACKGROUND.

WE BELIEVE WE HAVE DONE THIS. AT SNOHMASS WE WORKED VERY CLOSELY WITH CORNELL GROUP CHECKING IN GREAT DETAIL THE BACKGROUND SIMULATIONS. WE AGREED THAT THE MODELING IS ACURATE AND WE ARE NOT FOOLING OURSELVES.

WE ARE ONTO THE NEXT STEP NOW - DEMONSTRATE THAT THE IR REGION (MUSIC, CHAMBER, MAGNETS, ...) CAN INDEED BE BUILT. ALSO CHECK SIMULATIONS ON THE BACKGROUND.
Figure 1. Layout of the interaction region. Note the highly exaggerated vertical scale.
Controlling single & multibunch instabilities

※ It is relatively easy to maintain a small broadband impedance by building “smooth” vacuum chambers

※ Multibunch instabilities arise from the interaction of bunches with resonant structures - RF Cavities

※ High-order-mode fields excited by bunch N will act on bunch N+1, N+2... quickly driving the beam unstable

※ Solution is to damp the HOM’s while preserving the fundamental

PEP-II: Warm copper cavities with HOM dampers
KEKB: Two-prong approach
  (a) superconducting, wide-bore cavities with HOM dampers on the beampipe
  (b) warm copper cavities with HOM dampers
Fig. 5-114. Block diagram of the PEP-II longitudinal feedback system.
2) Quality Control without Compromising Int. Luminosity or Budget or Schedule

This was a constant vigil – it culminated with the strategy of *staged completion and testing* of the major subcomponents with real beam:

- e⁻ (e⁺) at end of New Injection Lines: Oct ’95 (97)
- e⁻ beam through 1/3 of HER: May ’97
- Stored e⁻ beam in High Energy Ring: June ’97
- e⁺ beam to Low Energy Ring Arc 7 Temp. Dump: Jan 98
First Collisions: July ‘98

Following extensive cosmic ray checkout, BABAR moves onto beamline: Feb. ‘99
### HER Commissioning Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Design</th>
<th>&quot;Best&quot; by Feb 22, 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>GeV</td>
<td>9.0</td>
<td>9.0, ramp to 9.1 and back</td>
</tr>
<tr>
<td>Single bunch current</td>
<td>mA</td>
<td>0.5</td>
<td>12</td>
</tr>
<tr>
<td>Number of bunches</td>
<td></td>
<td>1658</td>
<td>1658</td>
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<tr>
<td>Total beam current</td>
<td>A</td>
<td>0.995</td>
<td>0.75</td>
</tr>
<tr>
<td>y/x coupling</td>
<td>%</td>
<td>3.0</td>
<td>down to 0.8</td>
</tr>
<tr>
<td>RF voltage/cavity</td>
<td>MV</td>
<td>0.70</td>
<td>0.79</td>
</tr>
<tr>
<td>Synchrotron tune</td>
<td></td>
<td>0.045</td>
<td>0.0447</td>
</tr>
<tr>
<td>Bunch separation</td>
<td>m</td>
<td>1.26</td>
<td>0.63&lt;--&gt;2200</td>
</tr>
<tr>
<td>Chromaticity</td>
<td></td>
<td>-43, -54 (natural)</td>
<td>-43.6, -55.4 (natural)</td>
</tr>
<tr>
<td>Beam Lifetime</td>
<td>hours</td>
<td>4</td>
<td>10 hrs @ 50mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 hrs @ 270mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.5 hrs @ 725mA</td>
</tr>
<tr>
<td>Maximum Injection Rate</td>
<td>mA/s</td>
<td>2.1 @ 60Hz</td>
<td>2.5 @ 10Hz</td>
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</table>

### LER Commissioning Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Design</th>
<th>&quot;Best by Feb 22, 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>GeV</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Single bunch charge</td>
<td>mA</td>
<td>1.3</td>
<td>7.0</td>
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<tr>
<td>Number of bunches</td>
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<td>1658</td>
<td>1658</td>
</tr>
<tr>
<td>Total charge</td>
<td>A</td>
<td>2.14</td>
<td>1.171</td>
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<tr>
<td>RF voltage / cavity</td>
<td>MV</td>
<td>0.85</td>
<td>0.80</td>
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<tr>
<td>Synchrotron freq.</td>
<td></td>
<td>0.045</td>
<td>0.024</td>
</tr>
<tr>
<td>Bunch separation</td>
<td>m</td>
<td>1.26</td>
<td>1.26 &lt;-&gt; 2200</td>
</tr>
<tr>
<td>Beam Lifetime</td>
<td>hours</td>
<td>4 hours</td>
<td>50 min @ 800 mA</td>
</tr>
<tr>
<td>Maximum Injection Rate</td>
<td>mA/sec</td>
<td>5.9 @ 60Hz</td>
<td>3.0 @ 10 Hz</td>
</tr>
</tbody>
</table>

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The Accelerator Challenge
Overview

Goal of background measurements program is to find and fix problems before BaBar rolls in.

Multiple small detectors
  some optimized for expected backgrounds,
  some BaBar mimics and prototypes
  built and operated by BaBar physicists

Start during HER commissioning with simplified IR, compromise beampipe, subset of detectors

Requires detailed Monte Carlo simulation of both machine configuration(s) and detectors

June run allowed initial shakedown of first detectors

Fall run has given first real quantitative results

January run will have more intensive studies

April run will have full set of detectors, some built inside support tube, for both HER and LER

Lost Particle Backgrounds

Expected to be quadratic with beam current (linear term is possible from base pressure)

Detectors at various positions
  • PIN diodes in 4 places on beam pipe
  • Straw chamber at larger radius
  • Crystal Ring (2 crystals) at still larger radius
  • Water Cherenkov 4 meters upstream

Had 3 shifts in Fall dedicated to backgrounds vs I
  • Half-strength Q4/5, 8.5 GeV
  • Full-strength Q4/5, 8.5 GeV
  • Full strength Q4/5, 9 GeV

PIN diodes show large left-right effect from mask

Dedicated runs have relatively small differences, some evidence of improvement with time, but non-dedicated runs typically much worse

Quadratic term always present, sometimes large, but significant linear terms present too

Variation with position is plausible
Background Detectors in IR-2, Fall 1997

Crystal Ring
Straw Chamber and PIN Diodes on Beam pipe
Water Cherenkov and Hodoscopes
X-Ray Detector and TV Camera

PEP-II Interaction Region prior to installation of BaBar

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The Accelerator Challenge
### Background Detectors and Groups

<table>
<thead>
<tr>
<th>Detector</th>
<th>Purpose</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid State X-Ray Spectrometer</td>
<td>Synchrotron radiation spectrum</td>
<td>Colorado State U. + LBL</td>
</tr>
<tr>
<td>Silicon Diode Stacks</td>
<td>SR, lost-particle rate near beam pipe</td>
<td>Stanford U.</td>
</tr>
<tr>
<td>Straw Chamber (from Crystal Ball)</td>
<td>Lost-particles in tracking chamber</td>
<td>SLAC, Tennesseee, Ecole Polytechnique</td>
</tr>
<tr>
<td>Scanning Crystal Ring</td>
<td>MeV photons from lost-particle showers</td>
<td>LAPP (Annecy) + Saclay (France)</td>
</tr>
<tr>
<td>Water Cherenkov + Scintillator Hodoscope</td>
<td>BaBar DIRC backgrounds</td>
<td>U. Cincinnati + LBL</td>
</tr>
<tr>
<td>Mini Time Projection Chamber</td>
<td>High-granularity tracking chamber near beam pipe</td>
<td>Orsay (France) + LBL + U. Cincinnati</td>
</tr>
<tr>
<td>Silicon Strip Detector (BaBar prototype)</td>
<td>SR, lost particles next to beam pipe</td>
<td>UCSD+UCSC+UCSB + LBL + INFN + ...</td>
</tr>
<tr>
<td>Calorimeter Module (BaBar prototype)</td>
<td>Energetic photons, tracks (&gt;100 MeV)</td>
<td>SLAC</td>
</tr>
</tbody>
</table>
STRENGTH OF THE COLLABORATION

IN RECOGNITION OF:

- CHALLENGING PROJECT
- NEED FOR EARLY, DESIGN-LEVEL PERFORMANCE

WE HAVE FORMED A STRONG COLLABORATION TO BUILD THIS MACHINE

SLAC AND LBL HAVE A LONG TRADITION OF DEVELOPING, DESIGNING AND BUILDING FRONTIER ACCELERATORS. STORAGE RINGS WERE PIONEERED AT SLAC; SLAC AND LBL JOINTLY DESIGNED AND BUILT PEP. LBL IS CURRENTLY BUILDING THE ALS SYNCHROTRON RADIATION RING.

THE ADDITION OF LLNL, WITH ITS EXCELLENT TECHNICAL AND SCIENTIFIC BASE, ADDS SUBSTANTIAL STRENGTH

- B FACTORY JOINS THREE OF DOE'S PREMIER LABS IN A FRONTIER SCIENCE ENDEAVOR.

1991

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The Accelerator Challenge
$10^{34}$ to $10^{36}$ cm$^{-2}$ sec$^{-1}$

The mid 2000s to ??
NEEDS for Asymmetric machine (7 GeV (e-) + 4 GeV (e+)).

- SuperB with peak luminosity of $10^{36}\text{s}^{-1}\text{ cm}^{-2}$, integrating 75 ab-1 in 5 years.

  Background not exceeding too much the present Babar, thanks to low current, crossing angle and a careful design of the Interaction Region.

- One beam 80% polarized (High Energy).

- Possibility of running asymmetric at Charm threshold.
Basic concepts

* Two options:

* High currents
  – Very high currents
  – Smaller damping time \( \rightarrow \) High power components
  – Shorter bunches \( \rightarrow \) Costly to operate
  – Crab cavities for head-on collision
  – Higher power

* SuperB exploits an alternative approach, with a new IP scheme:
  – Small emittance beams (ILC-DR like)
  – Large Piwinski angle and “crab waist”
  – Currents comparable or smaller than present Factories

\( \rightarrow \) A lot of fine tuning!
## Super-B vs Super-KEKB

**Notes:**
- SuperB length w/o spin rotators.
- SuperKEKB luminosity assumes x2 gain from crab cavities.

<table>
<thead>
<tr>
<th></th>
<th>SuperB</th>
<th>SuperKEKB</th>
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<tbody>
<tr>
<td>Circumference (m)</td>
<td>1800</td>
<td>3016</td>
</tr>
<tr>
<td>Energy (GeV) (LER/HER)</td>
<td>4/7</td>
<td>3.5/8</td>
</tr>
<tr>
<td>Current (A)/beam</td>
<td>1.85</td>
<td>9.4/4.1</td>
</tr>
<tr>
<td>No. bunches</td>
<td>1251</td>
<td>5018</td>
</tr>
<tr>
<td>No. part/bunches</td>
<td>5.5x10^10</td>
<td>12/5x10^10</td>
</tr>
<tr>
<td>θ (rad)</td>
<td>2x24</td>
<td>2x15</td>
</tr>
<tr>
<td>ε_x (nm-rad) (LER/HER)</td>
<td>2.8/1.6</td>
<td>24</td>
</tr>
<tr>
<td>ε_y (pm-rad) (LER/HER)</td>
<td>7/4</td>
<td>180</td>
</tr>
<tr>
<td>β_y* (mm) (LER/HER)</td>
<td>0.22/0.39</td>
<td>3</td>
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<tr>
<td>β_x* (mm) (LER/HER)</td>
<td>35/20</td>
<td>200</td>
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<tr>
<td>σ_y* (μm) (LER/HER)</td>
<td>0.039</td>
<td>1</td>
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<tr>
<td>σ_x* (μm) (LER/HER)</td>
<td>10/6</td>
<td>50</td>
</tr>
<tr>
<td>σ_z (mm)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>L (cm^-2s^-1)</td>
<td>1x10^36</td>
<td>4x10^35</td>
</tr>
</tbody>
</table>

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**Talk of John Seeman: July 2008**

SLAC

PPA Particle Physics & Astrophysics
Super-B builds on the Successes of Past Accelerators

* PEP-II LER stored beam current (3.2 A in 1722 bunches (4 nsec) at 3.1 GeV at 23 nm with little ECI effect on luminosity.
* Low emittance lattices designed for ILC damping rings, PETRA-3, NSLC-II, and PEP-X. (few nm horizontal x few pm vertical)
* Very low emittance achieved in an ILC test ring: ATF.
* Successful crab-waist luminosity improvement at DAFNE in Frascati.
* Successful crab-cavity tests at KEKB at low currents.
* Spin manipulation tests in Novosibirsk.
* Efficient spin generation with a high current gun and spin transport to the final focus at the SLC.
* Successful two beam interaction region built by KEKB and PEP-II.
* Continuous injection works with the detector taking data (KEKB and PEP-II)

Talk of John Seeman: July 2008
Conclusions

• In the talks that follow, you will get a better appreciation of how well the challenges were met at PEP-II
• In summary, the design expectations for daily integrated luminosity were exceeded by a factor of 7
  – not that it was easy! But as third generation $e^+e^-$ storage rings we had a wealth of information to back up our design choices. The combination of outstanding accelerator and engineering talent and prudent management did the rest
• The situation with the SuperB factories is the same – applying the same principles as we did to PEP-II and KEKB is likely to lead to the same successful outcome